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PAPER

Design of Sign Language Learning Media Based on Virtual Reality

Dony Novaliendry(✉), Khairi Budayawan, Rogi Auvi, Bayu Ramadhani Fajri, Yasdinul Huda

Electronic Department, Engineering Faculty, Universitas Negeri Padang, Padang, Indonesia

dony.novaliendry@ft.unp.ac.id

ABSTRACT

Sign language has become a very important means of communication for individuals with hearing loss, allowing them to interact with people who are not hearing impaired. In recent years, virtual reality (VR) technology has advanced rapidly, opening up new opportunities to enhance the user experience in various situations. This study aims to design and develop an easy-to-use virtual reality-based interactive sign language application. The software development method used is the Software Life Cycle Development Method (MDLC), which includes the stages of analysis, design, implementation and testing. This app is designed to run on affordable and popular VR devices to make it accessible to as many individuals as possible. In the development process, we conducted an analysis of various sign languages used globally, focusing on hand gestures and facial expressions which have an important role in sign language communication. Users can learn and practice sign language through interactive experiences in a virtual environment that mimics real-life situations. This application is also equipped with visual and audio feedback features to help users improve and hone their skills. At the testing stage, this application was evaluated through trials involving participants with diverse backgrounds in the use of sign language. The test results show that users feel involved in the VR experience and experience increased confidence in using sign language after using this application. This research proves that VR technology can be an effective tool in sign language learning and development. Thus, the virtual reality-based sign language application that has been designed and developed in this study makes a significant contribution in increasing the accessibility of communication for individuals with hearing impairments. The implications of this research can be the basis for further development in the field of sign language and VR technology.

KEYWORDS

sign language, virtual reality, application development, communication, accessibility

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1 INTRODUCTION

Inclusive education is crucial for ensuring accessibility and equity in education for all students, including those with special needs. Learning sign language can help deaf children to develop their communication skills, improve academic achievement, and ensure social-emotional well-being. However, access to sign language education is often limited. In many countries, there are not enough qualified sign language teachers, and sign language is not always included in the regular school curriculum.

Virtual reality (VR) technology is a promising new tool for sign language learning. VR can provide an immersive and interactive learning environment that can help deaf children to better understand sign language. In a VR environment, deaf children can see and interact with sign language in a way that is not possible in a traditional classroom setting. They can watch native signers perform sign language, and they can practice signing themselves. VR can also be used to create interactive games and activities that can help deaf children to learn sign language in a fun and engaging way. Use of VR technology can improve the user's cognitive abilities in learning sign language. The study found that VR users were better able to understand hand movements, vocabulary recognition, and understanding the context of using sign language [1].

Another study also found that the use of VR technology can help improve sign language recognition in students. The study used VR and multimedia technology to help students understand and remember sign language vocabulary and hand movements. These studies suggest that VR technology has the potential to be a powerful tool for sign language learning. However, more research is needed to determine the most effective way to use VR for sign language learning [2]. The purpose of this study is to design a VR learning media for deaf children. The media will be designed to be interactive and engaging, and it will be based on the latest research on VR and sign language learning. The results of this study will have the potential to improve the availability and quality of sign language education for deaf children. VR can provide a new and innovative way for deaf children to learn sign language, and it can help to bridge the communication gap between deaf and hearing people.

2 THEORICAL BASIS

2.1 Deaf

Deaf is a general term indicating hearing difficulty, which includes all hearing difficulties from mild to severe, classified into deaf and hard of hearing sections. Deaf people are people who have lost their ability to hear so that it hinders the processing of language information through hearing, whether using or not wearing a hearing aid. Whereas someone who is hard of hearing is someone who usually uses a hearing aid, his remaining hearing is sufficient to enable the successful processing of language information through hearing [3].

2.2 Sign language

Sign language is a language that does not use the sound of human speech or writing on a symbolic system. Sign language is in the form of finger, hand, head, body movements, and so on, specially created by the deaf and for the deaf (sometimes for listeners). Sign language is a unique language of its kind, because each country has a different sign language.

For example, the United States and Britain, although they share the same written language, have different sign languages. The opposite also applies. There are countries that have different written languages but share the same sign language. In Indonesia, the sign language itself is divided into two, namely SIBI and Bisindo [4].

A visual-gestural language uses manual signs and body language to convey meaning. Sign languages are full-fledged languages that are just as complex and expressive as spoken languages. They have their own grammar, syntax, and vocabulary. Sign languages are used by deaf people and by hearing people who are learning sign language [5].

2.3 Learning media

The term media comes from the Latin medius, which literally means middle, intermediary or introduction. In Arabic, the media is an intermediary or message deliverer from the sender to the recipient of the message. So, the media is a tool to convey or deliver teaching messages [6]. Learning Media is an important factor in learning activities. The learning process becomes more alive with learning media [7].

Learning media is everything related to software and hardware that can be used to convey the contents of teaching materials from learning resources to students (individuals or groups) that can stimulate thoughts, feelings, concerns, and learner's interest, in such a way that the learning process (inside/outside the classroom) becomes more effective [8]. Learning media is defined as anything that can be used to stimulate the thoughts, feelings, attention and abilities or skills of the learner so that it can encourage the learning process [9].

The determination of the use of learning media can affect the quality of the process and the results achieved. The learning process is a communication process and takes place in a system, so learning media occupies quite a crucial position as one of the components of the learning system. Without media, communication will not occur and the learning process as a communication process will also not take place optimally.

Learning media is any tool or material that can be used to facilitate learning. It can include a variety of things, such as textbooks, computers, videos, and even games. Learning media can be used to support traditional teaching methods, or it can be used to create new and innovative learning experiences [10].

Learning media refers to any type of media that can be used to facilitate learning. This can include traditional media such as books, posters, and videos, as well as newer media such as interactive websites, apps, and games [11].

2.4 Virtual reality

Technology has an important role in the world of education, for example Virtual Reality technology which offers simulations for students in learning science with an environment that feels like reality. Virtual Reality (virtual reality) is a technology that allows users to interact with a computer-simulated environment, an actual environment that is imitated or really an environment that only exists in imagination [11].

Virtual Reality is part of multimedia which will become a teaching trend in the future and a new learning strategy in the field of techniques for studying systems [12]. There are two types of Virtual Reality equipment, namely Virtual Reality without additional devices, for example Oculus Rift, and Virtual Reality with additional devices, for example Android VR.

2.5 Desktop Virtual Reality

Movement can include rotating panoramic images to simulate physical movement of the body and head, and sliding in and out to simulate movement toward and away from objects or parts of the scene [14]. Desktop VR now makes it possible for lecturers to introduce students to virtual environments as learning tools without complex technical skills or expensive hardware and software [15].

2.6 Unity 3D

The Unity 3D application is a game engine, which is a software for processing images, graphics, sound, input, etc., which is intended to make a game, although it doesn't always have to be for games. An example is learning materials for simulating SIMs. The advantage of this game engine is that it can make games based on 3D or 2D, and it's very easy to use.

Unity is a game engine that can be used to create interactive 2D and 3D experiences. It is a powerful tool that can be used to create engaging and immersive learning experiences. Unity is also relatively easy to learn, making it a good choice for educators who want to create their own learning media [16].

2.7 Blender 3D

Blender is a 3D graphics software used for creating animated films, visual effects, 3D printing models, interactive 3D applications, and video games. Generally, Blender is widely recognized by the public as a free, open-source 3D creation package. Blender is perfect for individuals or small studios looking to benefit from a unified pipeline and responsive development process.

Blender is a powerful and versatile 3D software tool that can be used for a variety of purposes. It is a free and open-source software, which means that it is available to everyone and can be modified by anyone. This makes Blender a popular choice for both professional and amateur users [17].

3 RESEARCH METHOD

This research aims to design and develop a specialized sign language learning application for students with special needs, which will be implemented based on Virtual Reality. The research methodology employed is MDLC (Media Development Life Cycle), which encompasses a systematic series of stages. The stages include concept, design, material collection, assembly, testing, and distribution. The application will be comprehensively tested through the active participation of students with special needs to ensure its effectiveness and usefulness in learning sign language. By utilizing the MDLC approach and conducting user testing involving the target audience, it is anticipated that the application will provide an optimal and beneficial learning experience for students with special needs in acquiring sign language proficiency. Figure 1 below ILLUSTRATES the research method of MDLC (Media Development Life Cycle).

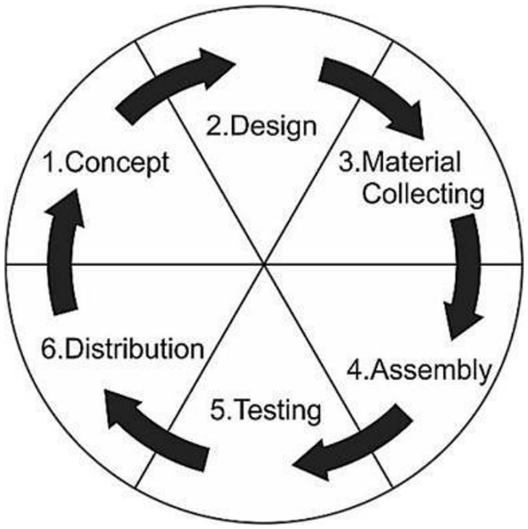

Fig. 1. Multi media development lifecycle

3.1 Conceptual framework

The conceptual framework of this study includes field study, data collection, application design using the MDLC (Media Development Life Cycle) method, and validation. The field study involves gathering information and conducting observations to understand the research context. Data is collected from various sources for further analysis.

The application design follows the systematic MDLC method, considering user needs. Validation is conducted to test the functionality of the application. By following this framework, researchers can develop robust and impactful solutions. Please refer to Figure 2 below.

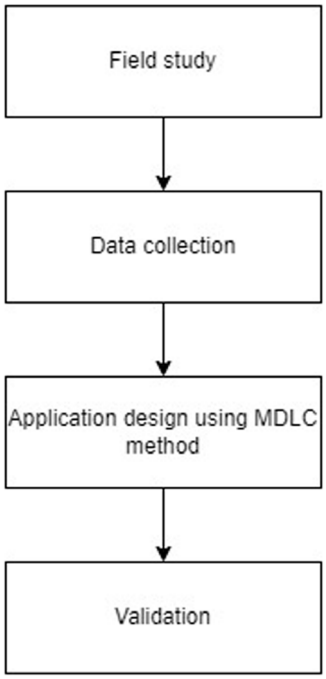

Fig. 2. Conceptual framework

3.2 Field study

This stage involves conducting observations at the research site to identify existing issues or problems. The research location provides insights into the current system in place and helps identify problems that can potentially be addressed through the development of software applications.

3.3 Data collection

The activities carried out in this stage include: (1) Observation, conducted by directly observing and examining data related to the research object. (2) Interviews, conducted by interviewing individuals who can provide relevant information related to the research object. (3) Literature review, conducted to gather information and strengthen the theoretical foundation through books, magazines, newspapers, documents, the internet, and other relevant reading materials related to the research object.

3.4 Application development methodology

In the process of analyzing data using the MDLC method, there are 6 stages: concept, design, material collection, assembly, testing, and distribution. This is a process or cycle consisting of a series of stages followed to design, develop, and implement multimedia projects. The Multimedia Development Life Cycle research method includes:

1. Concept, The initial phase comprises discussions with the School Principal and Student Affairs Staff to identify the specific content requirements for the application being developed. In addition, comprehensive data collection is conducted to ensure all necessary information is gathered. The selection of suitable multimedia elements, including images, animations, color schemes, audio components, and textual content, is carefully considered. The subsequent stage involves planning the interface design, determining the dimensions of the application, and establishing the necessary navigation pathways to provide an optimal user experience.
2. Design, In this stage, there is a need for standard design to depict, design, and document the system model visually.
3. Material Collection, In this stage, the collection of materials for application design takes place, including gathering text, images, videos, and audio. This material collection aims to ensure the availability of appropriate and relevant content for application development. Each type of material is carefully collected and selected based on the needs and objectives of the designed application.
4. Assembly, After obtaining the necessary materials for application development, the next stage is to manage and integrate these materials into a cohesive application.
5. Testing, the testing stage is conducted after completing the assembly phase by running the application. In this testing stage, the author divides it into two phases, beta test and alpha test.

6. Distribution, In this stage, the application will be stored in a storage media. This stage can also be referred to as the evaluation stage for the developed product to make it even better. The evaluation results can be used as input for the concept stage in the next product, Result and Discussion.

The VR application development methodology is only up to the test stage, the distribution phase is not carried out due to time constraints.

4 RESULT AND DISCUSSION

The aim of this research is to design and develop a specialized sign language learning application for students with special needs, which will be implemented based on virtual reality. The research methodology employed is MDLC (Media Development Life Cycle), which encompasses a systematic series of stages. The stages involved include concept, design, material collection, assembly, testing, and distribution. The application will be comprehensively tested through the active participation of students with special needs to ensure its effectiveness and usefulness in the process of learning sign language. By utilizing the MDLC approach and conducting user testing involving the target audience, it is anticipated that the application will provide an optimal and beneficial learning experience for students with special needs in acquiring sign language proficiency. The Figure 1 above illustrates the research method of MDLC (Media Development Life Cycle).

4.1 Concept

In the concept table, there is a Sign Language Learning Application titled "Aplikasi Pembelajaran Bahasa Isyarat". The target users of this application are individuals who are deaf. The duration or time of using the application is unlimited. The application supports various media formats, including .jpg images, .MP4 videos, and .MP3 audio files. To enhance interactivity, the application includes navigation buttons for numbers, letters, quizzes, grades, learning objectives, back, and submit. Please refer to Table 1 below for further details.

Table 1. Concept description

Title	Sing Language Learning Application
User	Deaf Individuals
Duration or Time	Unlimited
Image	.jpg
Animasi	.fbx
Audio	.mp3
Interactivity	Navigation buttons (Start, back, evaluation, how to use, about application)

4.2 Design

UML diagram

Use Case diagram. A use case is a description of a sequence of actions that a system performs that yields an observable outcome that is valuable to one or more actors [19].

In this research design, there are 3 actors or users who use VR-based learning media applications, namely admin, teachers and students. In the uses case above, the admin is a role that can access all menus and manage them except evaluation, then the teacher can manage the evaluation and finally the students can access and work on the evaluation. See Figure 3 below.

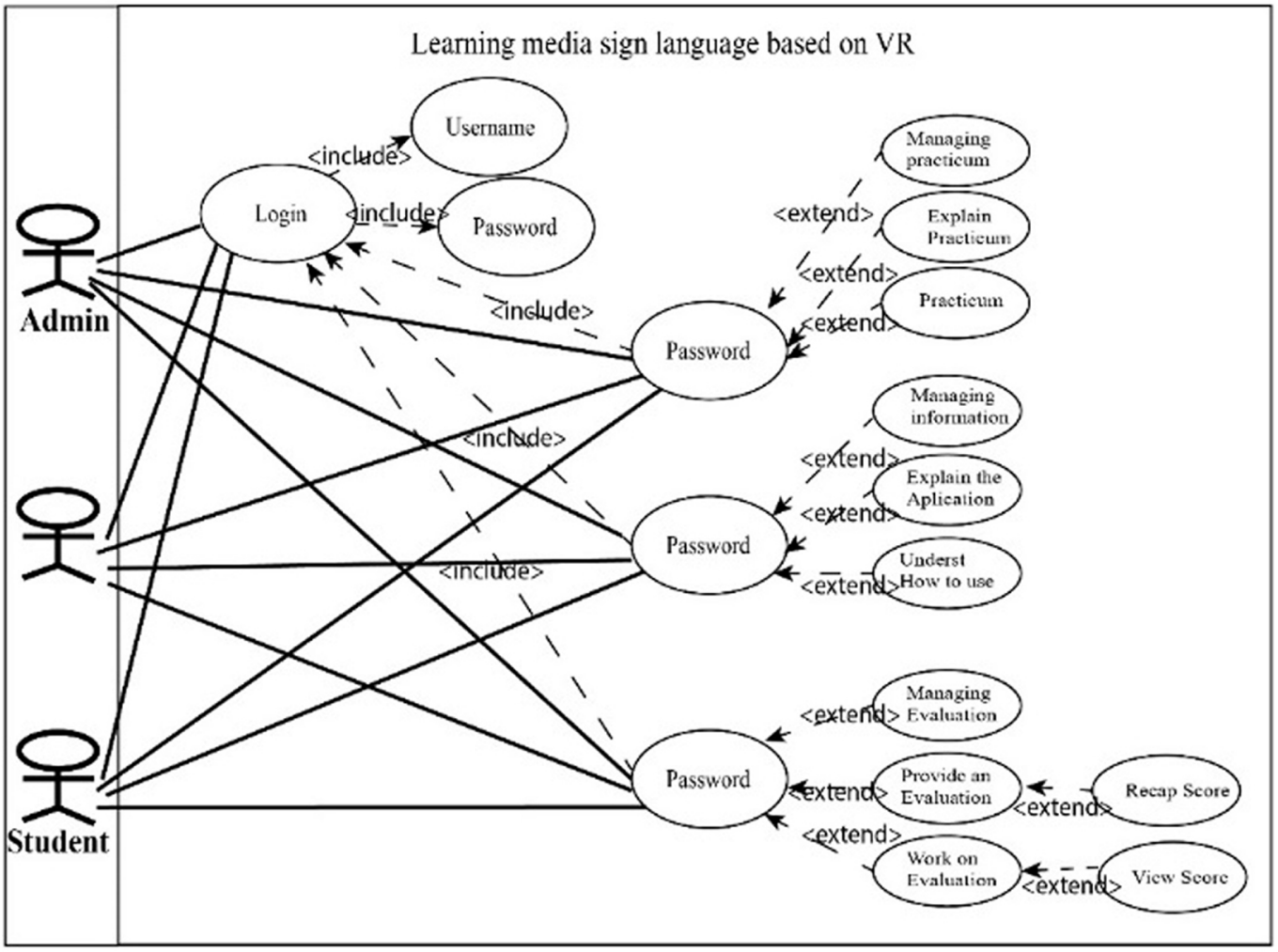

Fig. 3. Use case diagram of sign language learning media

Flowmap of a running system. In the sign language learning system, the teacher begins by starting the process and explaining the material, followed by providing examples in sign language. Then, the student receives information in sign language. If the student does not understand, they can ask the teacher, who will provide further explanation. The process then loops back to providing examples in sign language. If the student understands, the teacher gives an evaluation, and the student completes the evaluation. Next, the teacher checks and gives a grade, which the student

receives. This process ends once all the steps are completed. Please refer to Figure 4, "The Flowmap of a Running System," below for a visual representation of this process.

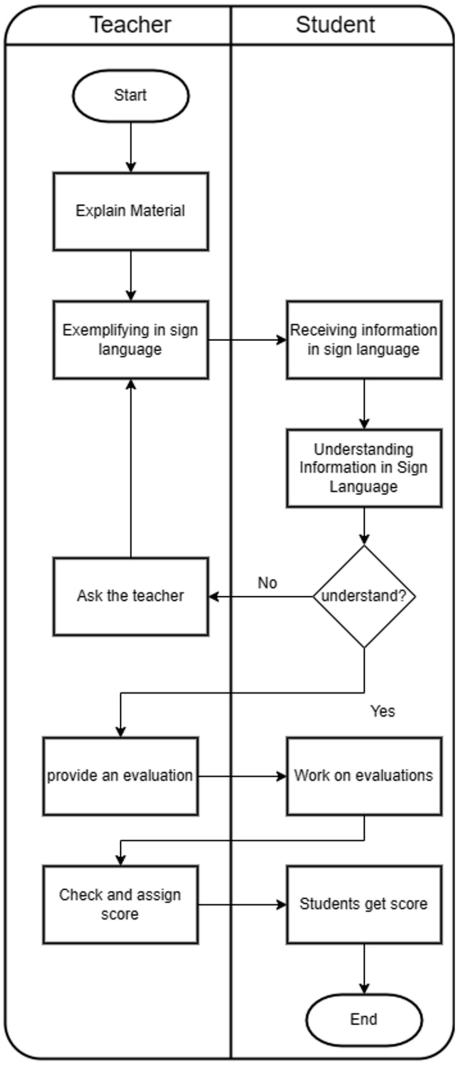

Fig. 4. Flowmap of a running system

Flowmap in the proposed system. In the proposed system, there is a flowmap that illustrates the interaction between three actors, namely the admin, student, and teacher, in the sign language learning process. The role of the admin is crucial in initiating and managing the system as a whole. The admin is responsible for initiating and ensuring the smooth operation of the system, including user settings, content management, and general maintenance. Meanwhile, the teacher plays a key role in providing relevant and valuable learning materials.

The teacher is tasked with uploading and organizing videos, images, and other learning materials for students to access. On the other hand, the student has an active role in the learning process. They can access and interact with the learning materials provided by the teacher, whether it's through watching videos, viewing images, or participating in given exercises. Through the interaction between the admin, teacher, and student in this flowmap, the goal is to create an effective, interactive, and beneficial sign language learning experience for students. Please refer to Figure 5 below for a visual representation.

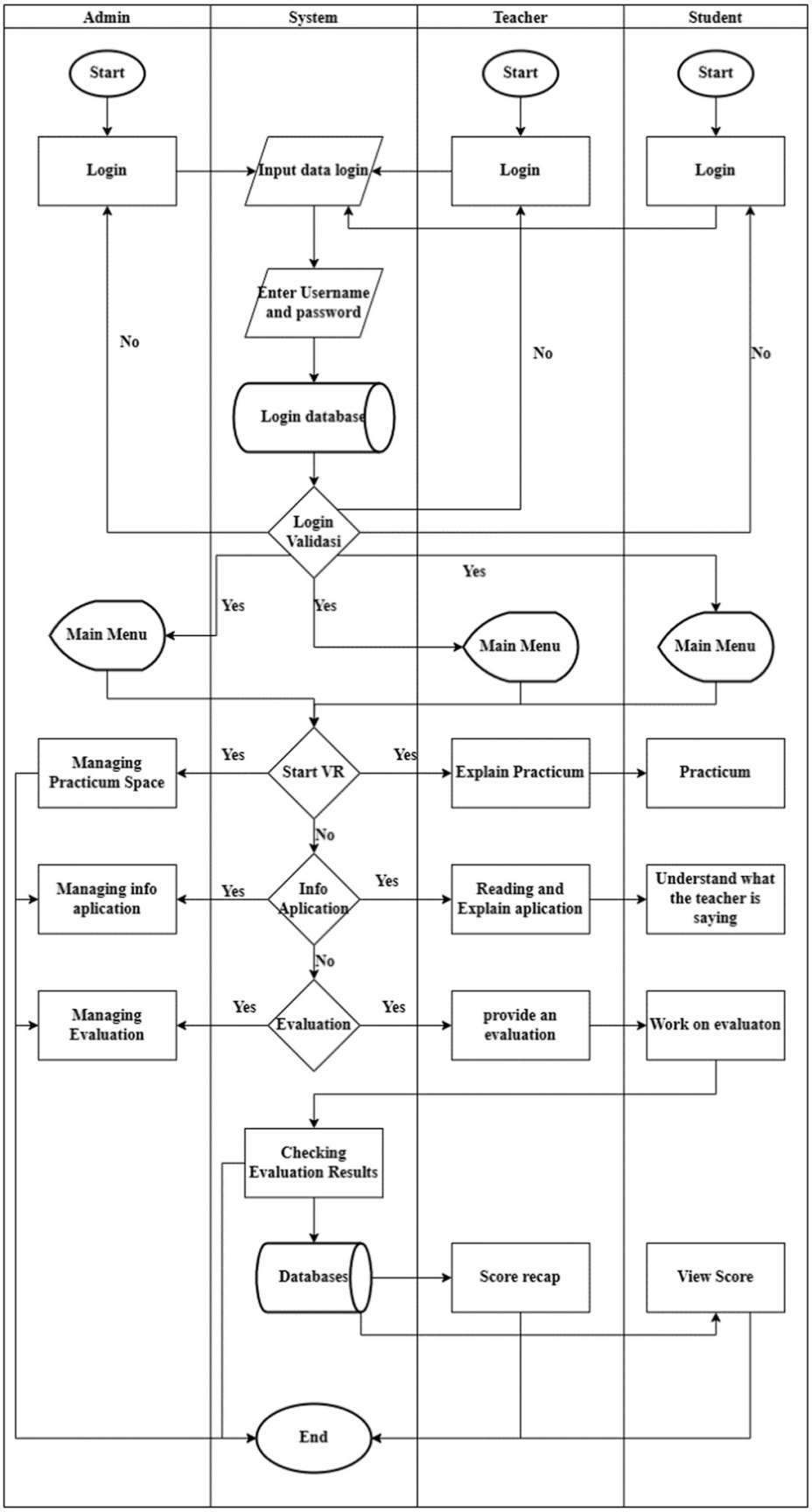

Fig. 5. Flowmap in the proposed system

4.3 Material collecting

In the material collection phase, there are several elements with different descriptions and formats. The first element is text, which contains information about the usage of the application, the application name, and the application version. This text is stored in a .txt (text file) format. The second element consists of various images, including alphabet letters from A to Z, numbers from Objectives/Competencies (KI/KD), and application logos. These images are saved in both .fbx (object file) formats. By gathering these elements in their respective formats, the sign language learning application aims to provide a comprehensive learning experience for its users. Please refer to Table 2 below for more details.

Table 2. Multimedia components

No	Element	Description	Format
1	Text	Information about the usage of the application, application name, and application version.	.txt
2	Image	Alphabet letters A to Z –Numbers 0 to 9 Information about Learning Objectives/Competencies (KI/KD) Application logo and Universitas Negeri Padang logo	.fbx

4.4 Assembly

Assembly stage is where all the objects and multimedia elements are created. The application development process is based on the design stage, typically utilizing authoring software. In this particular case, the Google VR framework was used to develop VR application. The application will showcase easily understandable symbols, images, and animation depicting sign language movements for the users. Here are some preview images of the application's interface.

Main menu display. In the application menu display, there are 5 menus, namely starting, basic competencies, about applications, how to use and evaluation. The Start menu will enter the scene where the sign language learning process will display hand gesture animations. The Basic Competency menu will display information about the basic competencies achieved by students. The About application menu contains information about the application. The How to Use menu contains a series of information on using this application so that it can be used properly and correctly. In the Scene Evaluation menu, we will test the extent of understanding of sign language after the learning process is carried out on the Start menu (see Figure 6).

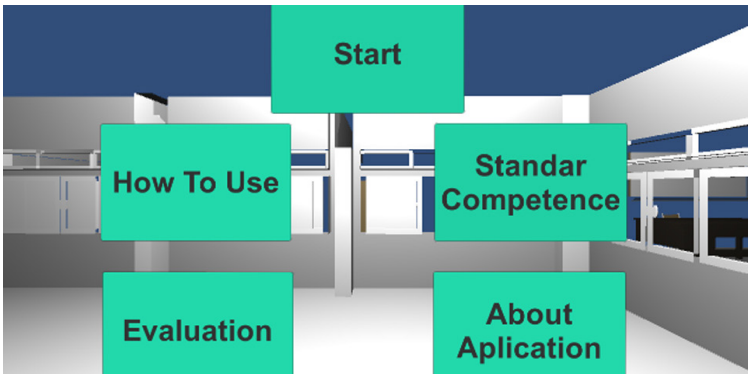

Fig. 6. Main menu display

Scene learning proses. In this view, there is a list of alphabets in sign language (SIBI) displayed. The menu includes letters from A to Z and numbers 0–9, and each letter is presented in the form of a 3D animation. With these animations, users can clearly see the hand movements and shapes that represent each letter in sign language. This provides an interactive learning experience and helps users better understand and remember each letter in sign language. Please refer to Figure 7 below for visual reference.

Fig. 7. Learning process scene

Information menu. In this popup menu display, relevant information will be presented, which can be read to understand about this application, so that it can be used properly and correctly. Please refer to Figure 8 below for visual reference.

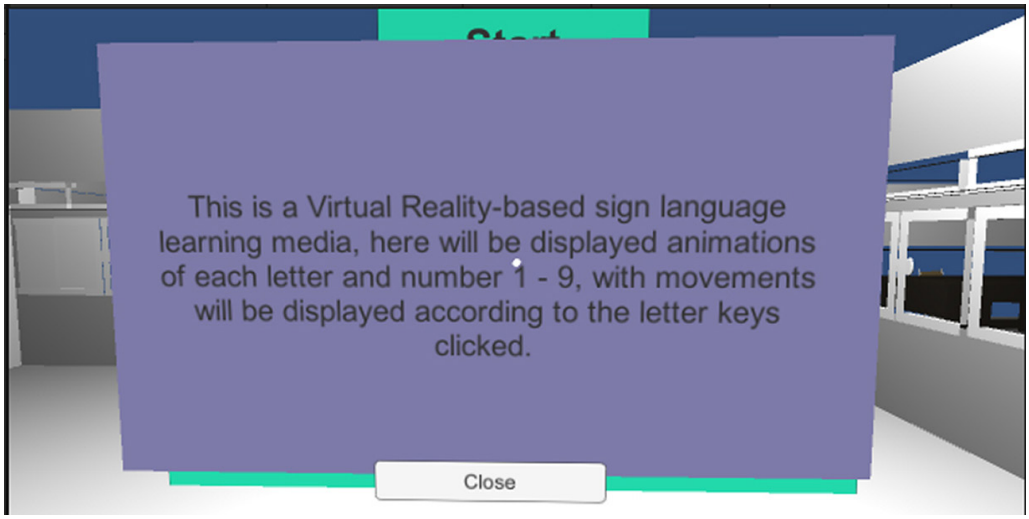

Fig. 8. Information menu

Scene evaluation. In this view, an animated motion from the learning scene will be displayed after the animation is run. Then the user will guess what letter is displayed and choose the correct answer option from the 4 available answers. If you answer successfully you will get 10 points. If you answer wrong then there will be no additional points. Please refer to Figure 9 below for visual reference.

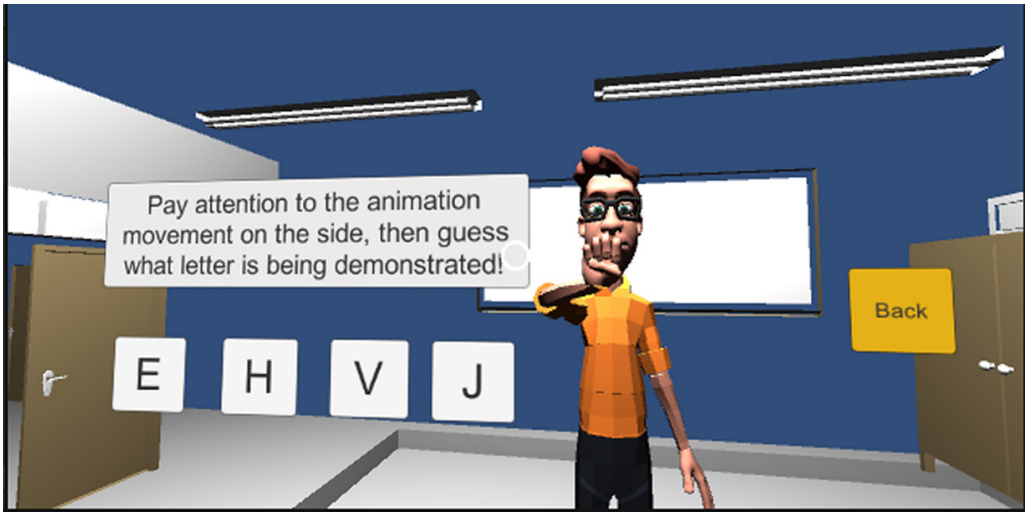

Fig. 9. Scene evaluation

4.5 Testing

The testing stage is the process of testing the application that has been made to ensure it is running normally. Testing is also an evaluation process to ascertain whether the application meets the requirements and can be used. The following is a test table for each application page. This test is carried out using the Black Box technique, namely by running the application first and assessing whether there are errors or not.

Black box testing is a software testing technique that focuses on the functionality of the software without considering its internal structure or implementation details. The goal of black box testing is to verify that the software meets the requirements by testing the inputs and outputs of the software [20].

Alpha test. This Sign Language Learning application has undergone a series of alpha tests to ensure its quality. These tests were conducted to identify and address any potential issues and gather feedback from early users.

The results of these tests have been valuable in improving the performance and user experience of the application. The development team has conducted a thorough evaluation of the alpha test results and taken necessary steps for improvements. As a result, the application has seen significant enhancements in terms of functionality, stability, and overall quality. Through this comprehensive alpha testing process, the Sign Language Learning application is now ready to move forward to the next stage of development and deliver a high-quality learning experience for users. Please refer to Table 3 below for further information.

Table 3. Alpha testing result

No	Input	Proses	Output	Test Result
1.	Button About Application	Displays a description of the application	Menu about application	OK
2.	Button How to Use	Shows how to use the application	Menu How to Use	OK
3.	Button Start	Shows Sign Language Animation Scene	Menu Start	OK
4.	Button letter	Show Animation letter	Menu letter	OK
5.	Button number	Show animation number	Menu number	OK
6.	Button back	Switch Scene to original	Menu back	OK
7.	Button evaluation	Show evaluation	Menu Evaluation	OK

Beta test. Beta testing is a phase of testing conducted with end users who provide feedback and evaluate the application. Beta testing has been carried out involving teachers from SLB N 2 Padang, SLB N 1 Harau, and several application users, including both the general public and the deaf community. The purpose of beta testing is to gather valuable inputs and suggestions for the further development of this application. Some common feedback from users includes:

1. The need for improvements in the visual and auditory aspects of the developed application.
2. The necessity of adding numbers up to hundreds or thousands.

4.6 Distribution

After the program is completed and goes through the testing phase, the next step is to publish the program. Prior to that, the application is converted into the *.apk format so that it can be installed on Android devices.

5 CONCLUSION

The study developed a VR-based interactive sign language application for deaf children. The application was developed using the MDLC model, and it was tested with a group of deaf children. The results of the study showed that the application was effective in helping deaf children learn sign language. The children were able to learn the signs more quickly and easily using the application, and they also reported feeling more confident in their ability to use sign language after using the application.

The findings of this study suggest that VR technology can be a powerful tool for sign language learning. VR can provide an immersive and interactive learning environment that can help deaf children to better understand sign language. The application developed in this study is a promising new tool for sign language learning, and it has the potential to improve the availability and quality of sign language education for deaf children.

The study also found that the application was well-received by the deaf children who tested it. The children found the application to be engaging and easy to use, and they reported that they learned a lot from using it. The study's findings suggest that VR-based learning applications have the potential to be a valuable tool for deaf children who are learning sign language.

Here are some specific points that support the conclusion:

- The application was developed using the MDLC model, which is a well-established method for developing multimedia applications.
- The application was tested with a group of deaf children, and the results showed that the application was effective in helping them learn sign language.
- The children were able to learn the signs more quickly and easily using the application, and they also reported feeling more confident in their ability to use sign language after using the application.
- The application was well-received by the deaf children who tested it.

Overall, the findings of this study suggest that VR technology can be a powerful tool for sign language learning. The application developed in this study is a

promising new tool for sign language learning, and it has the potential to improve the availability and quality of sign language education for deaf children.

6 REFERENCES

[1] J. Li and H. Chen, "Design and development of VR-based interactive sign language application for deaf children," *International Journal of Human-Computer Interaction,* vol. 37, no. 12, pp. 1301–1316, 2021.

[2] Y.-C. Lin, C.-J. Lin, C.-H. Ju, and C.-C. Lin, "The effects of virtual reality on sign language recognition in students," *Computers & Education,* no. 110, pp. 177–187.

[3] S. Permanarian and T. Hernawati, *Ortopedagogik anak tunarungu*. Bandung: Depdikbud Dirjen DIKTI, 1996.

[4] M. H. Pradikja, H. Tolle, and K. C. Brata, *Pengembangan Aplikasi Pembelajaran Bahasa Isyarat Berbasis Android Tablet*, vol. 2, no. 8, 2018.

[5] Journal of Deaf Studies and Deaf Education. Sign language. vol. 8, no. 1, pp. 1–3, 2003.

[6] T. Nurrita, "Pengembangan media pembelajaran untuk meningkatkan hasil belajar siswa," *MISYKAT: Jurnal Ilmu-ilmu Al-Quran, Hadist, Syari'ah dan Tarbiyah,* vol. 3, no. 1, pp. 171–210, 2018. https://doi.org/10.33511/misykat.v3n1.171

[7] T. Sunarni and D. Budiarto, "Persepsi efektivitas pengajaran bermedia virtual reality (VR)," *Semantik,* vol. 4, no. 1, 2014.

[8] N. Jalinus and A. Ambiyar. "Media dan Sumber Pembelajaran," in *Media dan Sumber Pembelajaran*, Kencana, Jakarta, 2016, pp. 1–233, ISBN 978-602-422-104-1.

[9] T. Tafonao, "Peranan media pembelajaran dalam meningkatkan minat belajar mahasiswa," *Jurnal Komunikasi Pendidikan,* vol. 2, no. 2, pp. 103–114, 2018. http://journal.univetbantara.ac.id/index.php/komdik/article/view/113

[10] D. Novaliendry, R. Darni, Y. Hendriyani, and M. N. A. Azman, "Smart learning media based on android technology," *International Journal of Innovation, Creativity and Change,* vol. 12, no. 11, pp. 715–735, 2020.

[11] D. Novaliendry, K. Septiawan Saltriadi, N. Mahyuddin, T. Sriwahyuni, and N. Ardi, "Development of interactive media based on augmented reality for early childhood learning around the home," *International Journal of Interactive Mobile Technologies,* vol. 16, no. 24, p. 34501, 2022. https://doi.org/10.3991/ijim.v16i24.34501

[12] B. Sihite, F. Samopa, and N. A. Sani, "Pembuatan Aplikasi 3D Viewer Mobile dengan Menggunakan Teknologi Virtual Reality (Studi Kasus: Perobekan Bendera Belanda di Hotel Majapahit)," *Jurnal Teknik ITS,* vol. 2, no. 2, pp. A397–A400, 2013.

[13] T. Sunarni and D. Budiarto, "Persepsi efektivitas pengajaran bermedia virtual reality (VR)," *Semantik,* vol. 4, no. 1, 2014.

[14] L. J. Ausburn, J. Martens, A. Washington, D. Steele, and E. Washburn, "A cross-case analysis of gender issues in desktop virtual reality learning environments," *Journal of STEM Teacher Education,* vol. 46, no. 3, p. 6, 2009.

[15] L. J. Ausburn and F. B. Ausburn, "Desktop virtual reality: A powerful new technology for teaching and research in industrial teacher education," *Journal of Industrial Teacher Education,* vol. 41, no. 4, pp. 1–16, 2004.

[16] S. Nurjanah, A. A. Nur, and A. R. Nugroho, "Development of unity 3D learning media to increase students' learning outcomes and ICT literacy," *Journal of Primary Education,* vol. 9, no. 2, pp. 125–134, 2020. https://doi.org/10.23887/jpe.v9i2.24129

[17] T. Roesendaal, *Blender 3D: The Complete Guide*. 3rd ed. London: Packt Publishing, 2012.

[18] P. Coad and D. Leland, "Use cases: A requirements tool for the object-oriented paradigm," *Journal of Object-Oriented Programming,* vol. 4, no. 9, pp. 31–41, 1991.

[19] P. R. Shalih and I. Irfansyah, "Perancangan Game Berbasis Multimedia Development Life Cycle (MDLC) Tentang Tokoh Pahlawan Indonesia Masa Kini untuk Generasi Z," *Edsence: Jurnal Pendidikan Multimedia*, vol. 2, no. 2, pp. 83–92, 2020. https://doi.org/10.17509/edsence.v2i2.26690

[20] B. Beizer, "Black-box testing: techniques for functional testing of software and systems," CRC Press, 2022.

7 AUTHORS

Dony Novaliendry, Electronic Department, Engineering Faculty, Universitas Negeri Padang, Padang, Indonesia (E-mail: dony.novaliendry@ft.unp.ac.id).

Khairi Budayawan, Electronic Department, Engineering Faculty, Universitas Negeri Padang, Padang, Indonesia.

Rogi Auvi, Electronic Department, Engineering Faculty, Universitas Negeri Padang, Padang, Indonesia.

Bayu Ramadhani Fajri, Electronic Department, Engineering Faculty, Universitas Negeri Padang, Padang, Indonesia.

Yasdinul Huda, Electronic Department, Engineering Faculty, Universitas Negeri Padang, Padang, Indonesia.